1. Aim of the project/research hypothesis

The most important goal of the project is to develop an innovative method of synthesizing graphene foams using precursors that are cheap, widely available, and with high resource levels. By definition, graphene foam is a three-dimensional material, with a structure of pores, mainly macropores, connected to one another by walls of comparable sizes. The idea behind synthesizing carbon materials is modification with the goal to meet conditions necessary to procure the desired material. For this purpose, we suggest synthesis using graphite/commercial graphene, which proceeds by filling the spaces between matrix walls with a hard/soft template, then using thermal treatment in the presence of separators and solvents to remove templates from the structure or treating their residue with appropriate substances for complete removal. The material so obtained will be subjected to instrumental analyzes in order to be fully characterized. An equivalent assumption of the project will be the introduction of heteroatoms, e.g., nitrogen, into the graphene structure. Thermal treatment of this doped material will produce desirable functional groups, responsible for electrode and conductive properties. In order to check the efficiency of doping, the products will undergo electrochemical examination, so that they may contribute to further use of graphene foam as electrode material in metal-air batteries and supercapacitors.

2. Research methodology

The development of an innovative and effective method of obtaining graphene foams doped with heteroatoms/transition metals will be centered on achieving the smallest possible number of steps. The design assumption is to modify the starting substance, the precursor, along with a relevant template in order to produce a foam-like material. An appropriate selection of templates, separators, or solvents will be used. Under the influence of carbonization at various temperatures, the desired graphene product will be obtained. Impregnating materials with reagents that contain heteroatoms or transition metals in the structure and subjecting them to carbonization will result in the incorporation of appropriate functional groups. This will increase conductive and electrode properties within the graphene structure. The impact of the substrates used, their concentration, and the temperature of carbonization on the preparation of graphene foams will be determined physico-chemically by means of instrumental analyzes. The reagent's influence on the quality of functional groups, which increase catalytic properties, will be assessed via electrochemical tests. In particular, the catalytic activity of obtained materials when used as electrodes in metal-air batteries or supercapacitors will be investigated.

3. Research problem/key results

Due to the fact that an important problem in modern research is the lack of particular attention to the costs of obtaining materials and their potential application, this project will develop new economical methods for transitioning from a laboratory to an industrial scale. The knowledge attained experimentally from the project will be used to direct practical applications of the materials obtained, find alternative materials for expensive platinum in metal-air batteries, use metal-free materials for the production of fuel cells, or create supercapacitors that can be successfully used in all types of electric vehicles and hybrids. The materials obtained in this project are likely to be naturally applicable as a source or energy storage device. Important industries, such as motors and electronics, will gain access to effective electrode materials for the construction of batteries or metal-air accumulators. To secure market dominance, it is important that the developed methods have a low production cost, are able to be transferred to an industrial scale, and create lightweight materials that are easily reprocessed. Until now, materials with several dozen percent of platinum were used, whose costs increase every year, making the production of electrodes or devices based on platinum impractical from an economic point of view.